We defined three periods of significant increased glacier flow/melting during the last 210 years. The first period (ca. 1800-1890), the supply of suspended material by meltwater into proglacial lakes of the East Sayan Ridge was not intense until 1850 and into proglacial lakes of the Kodar Ridge did until 1875. However, a rate of the supply of meltwater into proglacial lakes of the Baikalsky Ridge was high during the Little Ice Age and decreased at a transition from the Little Ice Age to the Recent Warming. During the second period (ca.1890- 1940) the regional glacier water balance were most likely positive. The third period (ca. 1940 - the present), the malting rates of glaciers located on the Baikalsky Ridge and the Kodar Ridge were moderate, in contrast to the East Sayan Ridge demonstrated the highest ratio of melting and changes in outlines during this period.

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FEATURES OF FORMATION OF AUTHIGENIC MINERALS IN HOLOCENE BOTTOM SEDIMENTS OF SMALL LAKES OF WESTERN SIBERIA

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Research of features of modern mineral formation and laws of generating of components of autigenic minerals in natural reservoirs of the Western Siberia is actual in connection with need of an assessment of influence of organic matter on processes of sedimentation and stability of biogeochemical cycles of macro elements (C, O, H, Ca, Si, Fe, etc.) in them. The biogeochemical aspect of sedimentology attracts wide attention of researchers, but due to the complexity of the object of study, many questions remain unclear [Lee, 1992 et.al.]. There is practically no information on the influence of biochemical transformation of organic substances on the mineral composition of bottom sediments of lakes in the process of their accumulation, in the early stages of diagenesis and their geochemical features.

This article discusses the features of modern mineral formation in small shallow lakes (171) located in taiga, forest-steppe and steppe landscapes in the south of Western Siberia. Primary field measurements of variables of different components of the lake system were carried out in all lakes. The selected samples were analyzed by a complex of modern analytical methods in the center for collective use of scientific equipment for multi-element and isotopic studies of IGM SB RAS, a detailed description of the methods is given in previously published articles [Strahovenko et al., 2014; Ermolaeva et al., 2016 et al.].

Strakhovenko, V. D. established that the bulk of the bottom sediments of the studied lakes were formed in the early stages of diagenesis is converted in a reducing conditions without H_2S or with H_2S by the representative material [Strahovenko et al., 2010]. Comparative analysis of petrochemical modules in various mineral types of bottom sediments of Siberian lakes showed that sediments are been represented by siltstone-pelite material with an admixture of carbonates. The level of average concentrations of elements in the terrigenous fraction in the bottom sediments of small lakes corresponds to the level of the upper continental crust.

During the expedition we visually observed the sedimentation of newly formed minerals on submerged algae, grains of terrigenous fraction on the interphase boundary “bottom sediments-water” on the surface of unattached algal and bacterial formations in the lakes. There are the presence of autigenic minerals in almost all lakes from different landscape zones by the study of samples of bottom sediments of lakes investigeted the modern complex of mineralogical methods. Methods of X-Ray diffractometry, electron microscopy and other were been used for analysis of mineral phases formed on non-fixed algae-bacterial formations (atmosphere-water interface), submerged algae and macrophytes (water-bottom sediment) and in bottom sediment. These materials do not discuss the hydrochemical deposition of alkaline metal salts and gypsum in the salty waters of this lakes of forest-steppe and steppe landscapes of Siberia.

The opal or chalcedony is added to the grains of terrigenous quartz in total mineral mass of lakes in all landscape zones of Western Siberia, The grains of the chalcedony are formed due to amorphous SiO_2 of diatoms (fig.1 a,b), by substituted mortmass of the macrophytes (photomorphs) (fig.1 (c) and globules (fig.1 d, e) which are have different genesis. The pyrite is the second minerals of the occurrence, but not in quantitative abundance (fig.2). Studies of samples of bottom sediments on the scanning electron microscope MIRA 3 TESCAN are show that pyrite is present in the form of individual crystals, crystal groups octahedral, cubic, pentagon dodecahedron (fig.2 (a), 1 to 2 µm in size) and not more than 0.01 mm in size in lakes of all landscape areas. Framboid pyrite formations are spherical aggregates ranging in size from 2 to 80 microns of densely packed microcrystals having a rounded shape at the initial stage of formation (fig.2 (b), octahedral or

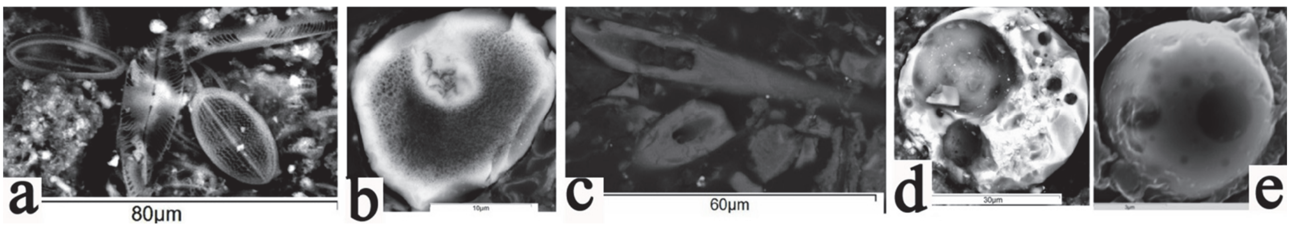

Fig.1. Electron microscope images: a, b – valves of diatoms, composed of SiO_2; c – SiO_2 have substituted mortmass of the macrophyte; d, e – globules of SiO_2 are formed by different genesis

Pyrite`s composition usually corresponds to the formula, sometimes Mn is present as isomorphic impurity (<1%), and the water impurity(up to 3%) is inherent in the initial stage of the formation of framboids. The availability of pyrite and its amount in bottom sediments does not depend on the total mineralization of water and its ion composition. It is known that as aresult of microbiological processes of decomposition of organic matter occurs recovery Fe3+. Under conditions typical for the interface of media (water-algae (OM)), water-BS) anaerobic microorganisms are able to oxidize H_2S, while receiving sulfur (Potekhina, 2005). It is important that the sulfur obtained during oxidation of H_2S is color-coded; the processes of colloid coagulation lead to the formation of the characteristic framboidal shape of pyrite, regardless of further pyrite formation occurs due to the microbiological process or hemogenic (Belogub, 2009). Sometimes the aggregates of the pyrite takes the place of the macrophyte detritus – pseudomorphs (fig.2 (e).

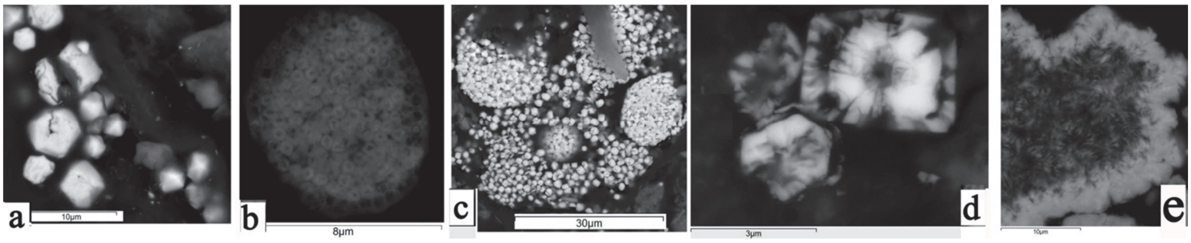

Fig. 2. Electron microscope images of the pyrite: (a) – pyrite individual crystals, crystal groups in the form of octahedral, cubic, pentagon dodecahedron habitus in the bottom sediments of the Lake Barchin; (b) – framboid pyrite formations are spherical aggregates of densely packed microcrystals having a rounded shape at the initial stage of formation in the bottom sediments of the Lake Peschanoe; (c) – framboid pyrite formations are spherical aggregates ranging in size from 2 to 80 microns of densely packed microcrystals in the bottom sediments of the Lake Bergul; (d) - recrystallization of the framboid pyrite formations in covering crystals in the bottom sediments of the Lake Kukley; cubic (fig. 2 c), up to 20 microns in size in the recrystallization of the framboid pyrite formations in covering crystals (fig.2 d)

The calcite – dolomite carbonates, aragonite are widely distributed among modern autigenic minerals of small lakes in Siberia, occasionally siderite, rhodochrosite, magnezite. It is established that the minerals form thin films on the primary frame of algae, consisting of fine-grained releases of aragonite and /or low-Mg calcite that decompose during the life of algae at the boundary of the media “water-algae” in lakes of any landscape zone and mineralization of waters from ultra frech to brine (fig. 3). It was found that the original except aragonite, the composition of thin films on the primary frame of algae (fig. 3 (a) submitted by either magnesium sulfate (fig. 3 (b) or magnesium carbonate (fig. 3 (c). The formation of the first magnesium minerals may be due to the presence of magnesium in the chlorophyll molecule. It is known that photosynthetic organisms, extracting carbon dioxide dissolved in water, changing the pH of the medium in the alkaline side, cause precipitation of dissolved carbonates. As a result of the activity of bacteria and fungi that live on the bottom in the first cm of bottom sediments in large quantities, anaerobic degradation of the original organic matter of silt produces gases – CO_2, H_2S, NH_3 etc. The roundish micrograins of the Ca-excess dolomite (fig. 4 a) and high-Mg calcite (fig. 4 b) are precipitated from water in the bottom sediments after contributes to the dissolution and disappearance of magnesium sulfates and carbonates, partially aragonite in lakes with a hydrocarbonate sodium content in water more than 4 g/l. The aggregates of the aragonite, low-Mg calcite (fig. 4 (c)) and calcite (fig. 4 (d). are accumulated in all lakes with a different type of water. The formation of aggregates of the calcite or aragonite composition are one of the most common cases of fossilization (fig. 4 (e).

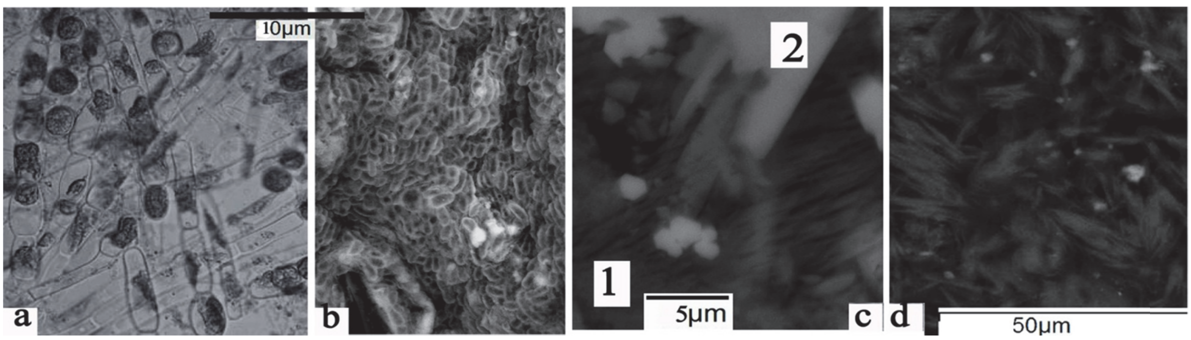

Fig. 3. (a) Foto *Ctenocladus circinnatus Borz* from the Kulunda Steppe soda lake Tanatar VI (b). Scale bar 10 μm [Samylina et. al., 2014]; (b) Electron microscope images of mineral (Mg-sulfate) films on the algae-bacterial consortia from bottom sediment of Lake Petuchovskoe; (c) – Electron microscope images of mineral (Mg-carbonate – 1), films on the algae-bacterial community from bottom sediment of Lake Danilovo, and replaced its calcite $CaCO_3$ – 2; (d) – Electron microscope images of mineral (Mg-carbonate) replaced algae-bacterial community from bottom sediment of Lake Tanatar-6

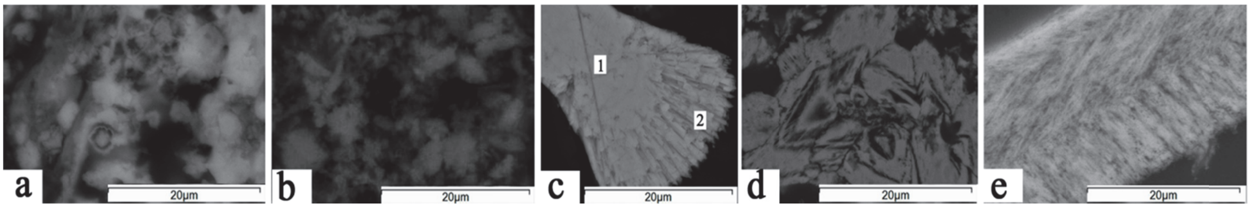

Fig. 4. Electron microscope images of minerals (a) – roundish micrograins of the Ca-excess dolomite; (b) – micrograins of the high-Mg calcite; (c) – the crystals of the aragonite - 1, low-Mg calcite – 2; (d) – the crystals of the calcite; (e) the aggregates of the calcite takes the place of the macrophyte detritus

Thus, it is established that in lakes there is a modern autigenic mineral formation with active participation of organic matter on two borders of the phase division: "water-atmosphere", "water-bottom sediment". Minerals that decompose during the life of algae can be composed of chalcedony (diatoms), or form thin films on the primary frame of algae, consisting of fine-grained, aragonite, sulfate and magnesium carbonates. Low-Mg calcite, aragonite, pyrite, and pyrite accumulate in the bottom sediment as a result of bio-hemogenic deposition. The Ca-excess dolomite, high-Mg calcite accumulate in the bottom sediment of lakes with hydro-carbonate sodium composition of waters, and lakes with chloride and chloride-sulphate sodium – magnesium composition falls out the crystals of the calcite.

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